Retooling for Wind

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Towers Operations

- Trinity Structural Towers (Clinton, IL; Tulsa, OK)
- SIAG Aerisyn (Chattanooga, TN)
- Ventower (Madison, MI)
- Thomas & Betts (Memphis, TN)
- Tower Tech (Manitowoc, WI; Abilene, TX)
- Katana Summit (Columbus, NE)
- DMI (West Fargo, ND; Tulsa, OK; Ft. Erie, ON)
- Dragon Wind (Lamar, CO)
- Vestas (Windsor, CO)
- SMI & Hydraulics (Porter, MN)
- Ameron (Rancho Cucamonga, CA)

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Blades Operations

- Suzlon (Pipestone, MN)
- LM Windpower (Grand Forks, ND; Little Rock, AR)
- Siemens (Fort Madison, IA)
- Gamesa (Ebensburg, PA)
- Molded Fiberglass (Gainesville, TX; Aberdeen, SD)
- TPI Composites (Newton, IA)
- Vestas (Brighton, CO)
- Nordex (Jonesboro, AR)
- Energy Composites Corp (Wisconsin Rapids, WI)

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Gearbox OEMs

- Winergy Drive Systems (Elgin, IL)
- GE Transportation (Erie, PA)
- Clipper Windpower (Cedar Rapids, IA)
- Brevini (Muncie, IN)
- Moventas (Faribault, MN)
- Z-F (Gainesville, GA)
- Bosch-Rexroth (TBD)

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What are OEMs doing?

- OEMs already in operations
  - Reviewing Supply Chains: domestic options
  - Managing growing Warranty Requirements
- OEMs Building New Plants
  - Creating start-up Supplier Network
- OEM Advance teams
  - Looking for sales opportunities
  - Evaluating possible plant sites
  - Identifying Supply Chain Resources

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Wind Turbine OEMs don't call back. Why not?

- Purchasing Groups are BUSY
- New people in new jobs
- Access to technical information
- Global price points for components
- Extended supplier qualification process
- How to find, select best partners?
- As a manufacturer, how to engage?

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Integrator
TOWER Supply Chain

- Steel mills – plate
- Fabricators – Tower Top
- Forgers – Flanges
- Small Components
  - Door frames
  - Platforms
  - Ladders
  - Lighting
  - Fasteners
  - Electricals
  - Coatings
  - Cable

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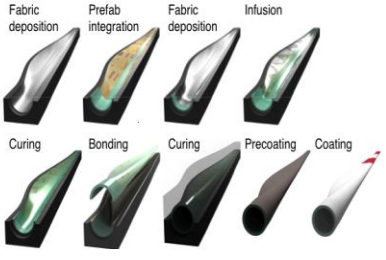
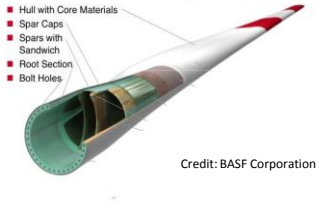
Blades from Integrator



Blade Components



Credit: BASF Corporation

2nd, 3rd Tier Opportunities

Core Materials Fiber glass Carbon fiber Mesh Resins
Protective Films Dispensing/Dispensing/Vacuum Equipment
Coatings Lightning/Grounding Barrel Nuts Studs

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Blades – Root End

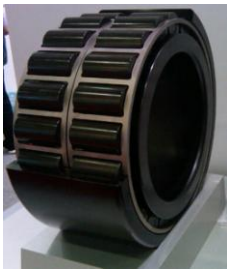
Composite Nacelle Housing Panels

Credit: Nordex SE

Nacelle Machine Head
with Rotor Hub

Composite Nacelle
Housing Panels

Major Bearings



2nd, 3rd Tier Opportunities

Roller Elements Forged Rings

Seals Lubricating Systems Lubricants

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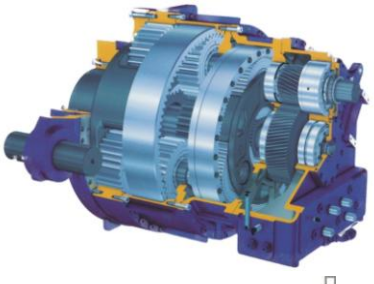
Gearing and Drives



2nd, 3rd Tier Opportunities

Actuators Bearings Brakes Gears

Cooling Systems Drive Motors Housings

Lube Systems Pitch Drive UPS Shafts

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The Numbers Are Growing…

U.S. Installed Wind Power Base >100kW

	Accumulated MW	Accumulated Turbines	
2005	9,014	5,288	
2006	11,476	6,706	
2007	16,724	9,893	
2008	25,076	14,805	(14,000+ Out of Warranty)
2009	35,065	20,861	
2010	40,180	23,735	
805 U.S. Wind Farms (10 in Indiana)			
Indiana	1,339	798	

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Credit: AWEA

Hurdles for Manufacturers: The Three Cs

Competitveness

- Operational Efficiencies
  - Take time and waste out of the process
  - World Class Lean – 20% reductions/yr!!
- Subsidized Off-shore competition
- Lack of Standards
  - Parts
  - Packaging
  - Inspections
- Cost of Raw Materials

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Hurdles for Manufacturers: The Three Cs

Capital

- Specialized Equipment
  - Portable CMM
  - Specific Tooling
- Facilities Investments
  - Cranes/Modernizing
  - Cleaning/Expansions

Other Investments:

Certifications (ISO,AWS)
Quality Systems
Supp Qualification Process

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Hurdles for Manufacturers: The Three Cs

Connections

- Hard to Connect with OEMs
- Few of Them / Lots of Us
- New US based purchasing
- Where do I fit??
  - What are they sourcing
  - Who is buying - OEM/Tier 1/ Tier 2??

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Anatomy of a Wind Turbine

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Turbine Components

There are over 8000 components in a turbine, including:

Towers
- Towers
- Ladders
- Lifts

Rotor
- Hub
- Nose Cone
- Blades
- Composites
- Blade Core
- Pitch Mechanisms
- Drives
- Brakes
- Rotary Union

Nacelle
- Nacelle Cover
- Nacelle Base
- Heat exchanger
- Controllers
- Generator
- Power Electronics
- Lubricants
- Filtration
- Insulation
- Gearbox
- Pump
- Drivetrain
- Ceramics
- Shaft

Foundation
- Rebar
- Concrete
- Casings

Other
- Transformers
- Bolts/Fasteners
- Wire
- Paints and Coatings
- Lighting
- Lightning Protection
- Steel Working/Machining
- Communication Devices
- Control and Condition Monitoring Equip.
- Electrical Interface and Connections
- Batteries
- Bearings
- Brakes

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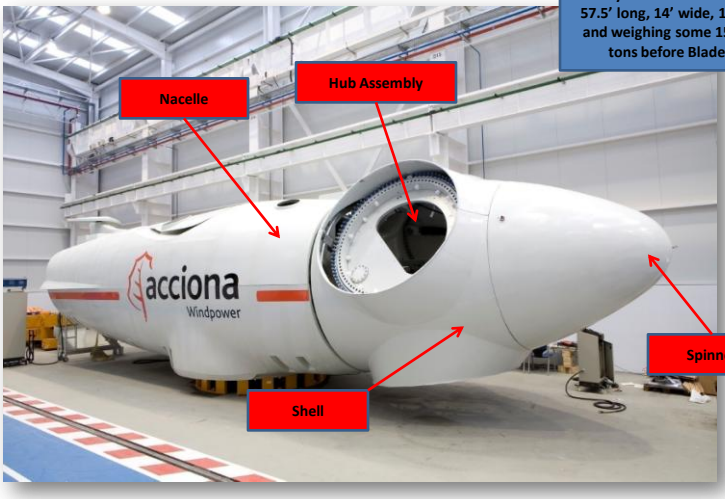
Credit: AWEA

Machine Head / Nacelle



Credit: Acciona

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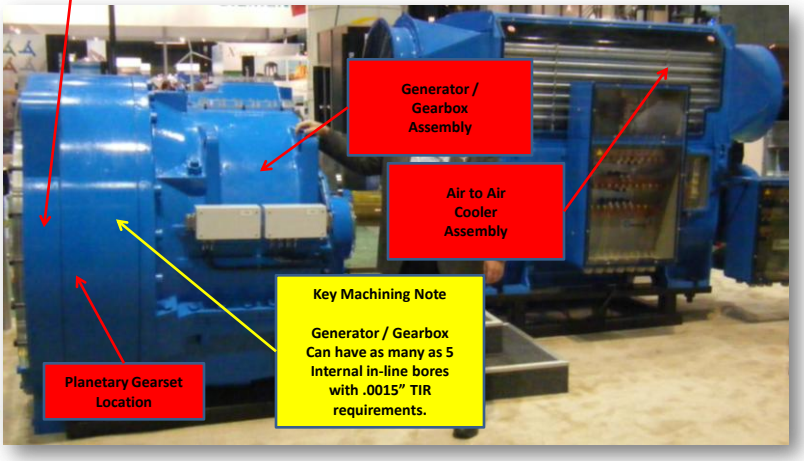
Gear Box & Generator



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Blades

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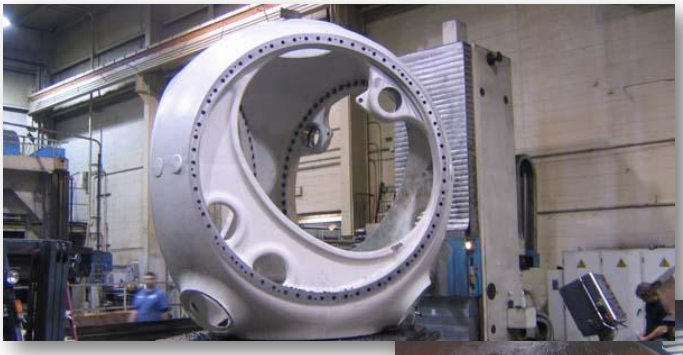
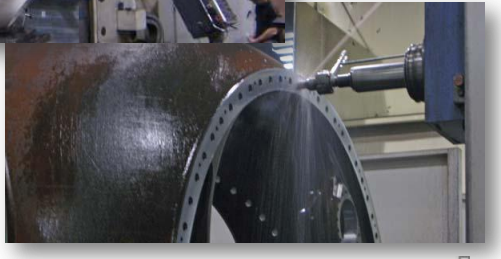
Credit: U.S. Department of Energy
"20% Wind Energy by 2030" Report

Hub





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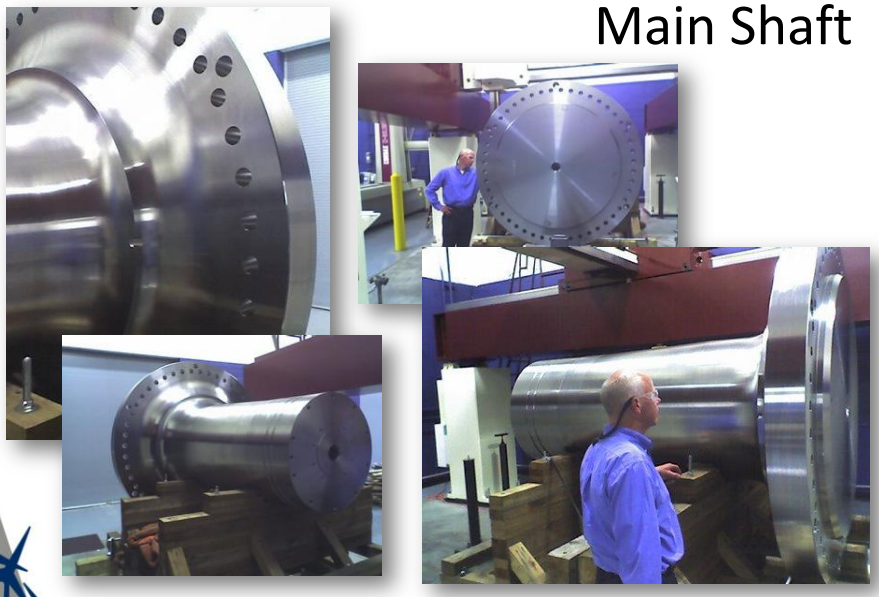
Main Shaft



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Towers

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Credit: Carell Corporation

Foundation Construction

- Foundation layout: marking the seal slab for layout of rebar, forms and bolt cage.
  - Same crew as seal slab.
- Bottom rebar mat installation: First layer of rebar.
  - Equipment: 10,000 lb. fork lift.
  - Materials: Rebar, tie wire, rigging.
  - Contractor: EPC/BOP, Foundation, Excavation

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Foundation Construction

- Bolt Cage Installation: Assembling all of the bolts that will attach the tower base to the foundation.
  - 12,000 lb. forklift, enclosed trailer, 18' flatbed trailer, 2 trucks.
  - Mat'ls: Anchor bolts, PVC sleeves, nuts & washers; Templates & embed rings;
  - Contractor(s): EPC/BOP, excavation, Foundation, Ironworker or rebar sub.
  - Crew: 1 Foreman, 5 Laborers

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Remainder of Foundation Construction

- Top Mat rebar installation: Installing second mat of rebar.
- Base Form installation: forming base of foundation for first pour.
- Grounding: Driving copper rods into ground, attaching copper cables to foundation steel.
- Base concrete pour: First pour.
- Install pedestal steel: Rebar to complete pedestal portion of foundation

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So Far Discussed

- Pre-construction
- Site clearing
- Site excavation
- Foundation construction
- Subcontractors used
  - Environmental
  - Geotechnical services
  - Excavation
  - Concrete Supplier
  - Foundation
  - Iron worker (rebar)
  - Electrical
- Materials
  - Aggregate
  - Geotextile
  - Concrete
  - Rebar & wire
    - 20 – 50 tons per foundation
  - Copper
  - Wood
    - Forms
    - Laydown
    - Dunnage

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Vertical Construction

- Major Players
  - Supply Logistics Service Provider
    - Typically hired by OEM
    - Site logistics
      - Hired by 1st tier contractor
  - Wind Farm Construction General Contractors
    - Hired by Developer, then hire almost all subcontractors

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Logistics Examples

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Site Logistics

- Moving in cranes to perform the vertical construction.
- 80 mtr. hub height
  - 90 - 800 ton cranes
  - 14 -28 truckloads
  - 2-5 day teardown & rebuild
- 100 mtr. tower
  - Up to 25% more Cost

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Logistics Services Companies

- Examples of supply LSP's
  - ATS
  - Trans Project
  - Vectora Transportation
  - TMO
  - Baltship

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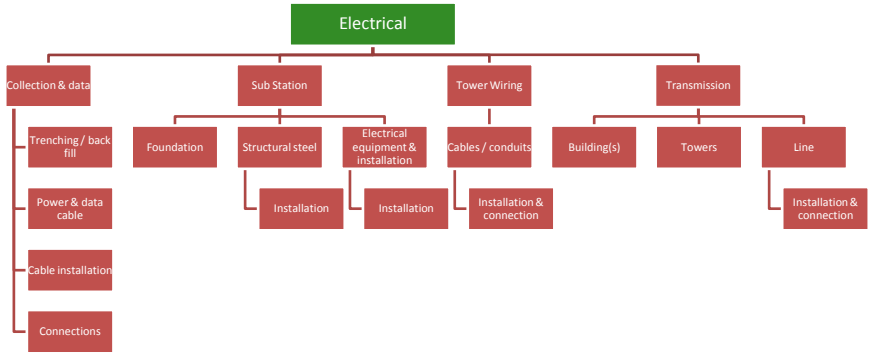
Electrical Supply Chain



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Trenching & Collection

- Trenching
  - Excavation
  - Foundation
  - Back fill
- Cabling
  - Connections

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Sub Station Construction

- Foundation
- Structural Steel
- Components
- Connection

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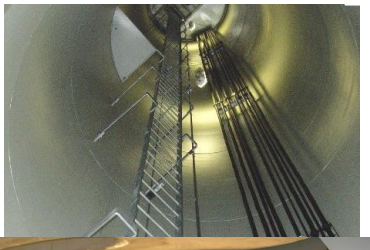
Tower Wiring

- Process of installing all necessary tower wiring and completing terminations at base of tower to tie to the grid



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Inside the Nacelle

Distribution

- Grid connection
  - Above ground
    - Tower erection
  - Below ground
    - Trenching
  - HV cabling
  - HV connection

Distribution Opportunities

- Steel structure erection
- Cabling
- Electrical connection

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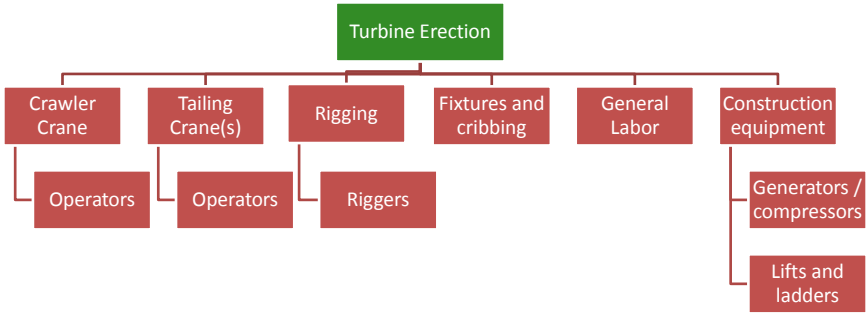
Special Construction



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Turbine Assembly Process

- Set Base & Midsection
  - Equipment: Base midcrane, Rough Terrain Crane, Rough Terrain Forklifts, pickup trucks.
  - Materials: Dunnage, Crane Mats, Rigging, Turbine Components

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Turbine Assembly Process

Rotor Build

- Equipment: Rotor Build Crane, Rough Terrain Forklifts, Pickup trucks
- Mat'ls: Dunnage, Rigging, Crane Mats, Turbine Components

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Turbine Erection Process

- Install Top, Nacelle & Rotor
  - Equipment: Main Crane, Tail Crane, Rough terrain Cranes, Rough Terrain Forklifts, Pickup Trucks

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Turbine Erection Process

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Turbine Erection Process

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Turbine Erection Process

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Turbine Erection Process

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Turbine Erection Process

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Support Operations

- Operations and Maintenance Buildings
- Data cabling and collection
- SCADA installation (Supervisory Control & Data Acquisition)

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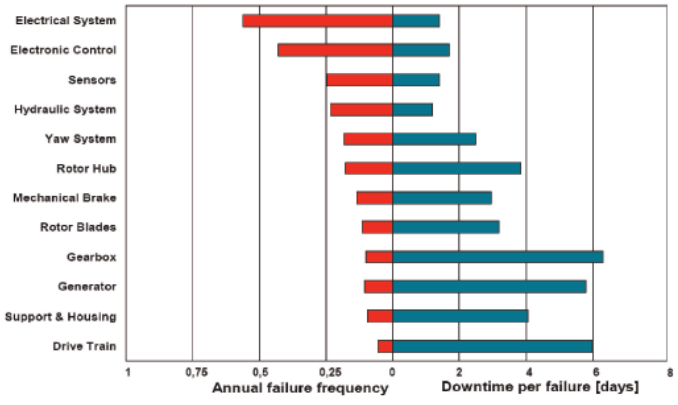
Annual Failure Frequency: Downtime



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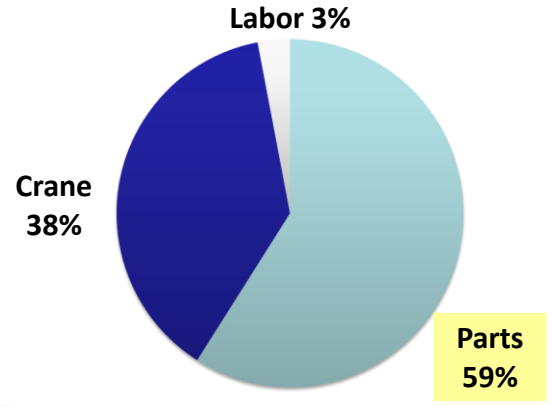
Credit: ISET German Wind Energy

Large Component Replacement Cost Breakdown



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O&M Job Opportunities

- Direct
  - Site Manager
  - WT Technicians
    - Mechanical
    - Electrical
  - Data Monitoring
- Indirect
  - Contracted Repair
  - Service Parts
  - Rebuild
  - Cleaning
    - Tower, Blades, Nacelle
  - Cranes
  - Blade Repair
  - Tools & Safety Equipment

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